

degree, the power of absorbing the ultra-violet rays of the spectrum, though they are inferior in this respect to benzene and its derivatives, to which class of bodies they are so closely allied.

2. Terpenes with the composition  $C_{15}H_{24}$  have a greatly increased absorptive power for the more refrangible rays, that is to say, they withstand dilution to a greater extent the greater the number of carbon atoms in the molecule.

3. Neither the terpenes themselves nor the oxidised or hydrated derivatives occasion absorption bands under any circumstances when pure, but always transmit continuous spectra.

4. Isomeric terpenes transmit spectra which generally differ from one another in length, or show variations on dilution.

5. The process of diluting with alcohol enables the presence of bodies of the aromatic series to be detected in essential oils, and even in some cases the amount of these substances present may be estimated.

Several diagrams in illustration of the kind of absorption exerted by the different substances are presented with the complete paper.

### III. "Preliminary Note on Magnetic Circuits in Dynamo- and Magneto-Electric Machines." By Lord ELPHINSTONE and CHARLES W. VINCENT, F.R.S.E., F.C.S., F.I.C. Received July 26, 1879.

The experiments which form the subject of the present note were made in connexion with an investigation as to the best form for the construction of a dynamo-electric machine, intended to furnish currents of high intensity in great quantity. The principle deduced applies equally to magneto-electric machines.

The source of power in all dynamo-electric machines being electro-magnets whose cores are already slightly magnetic, it appeared to us necessary to consider the conditions under which the initial force of such machines is best obtained.

For this purpose we made use of a  $\text{U}$  electro-magnet having a core of soft iron 2 inches in diameter and 36 inches long. The arms of the  $\text{U}$  were 4 inches apart. The exciting helices were two sheet copper reels, 12 inches long, fitting closely upon the uprights of the  $\text{U}$ , but readily removable. Each of these reels was coiled with 200 yards of No. 14 double covered copper wire.

Two cores of soft iron, of the same diameter; and each  $12\frac{1}{4}$  inches long, and which could be magnetised by the same helices, were also employed.

The principal armature was of soft iron, 8 inches in length, by 2 inches in width, and 1 inch thickness, rounded at the ends. Its face

fitted approximately close to the poles of the U magnet, whose faces it completely covered when placed upon them.

Other armatures and magnets were employed, the form of which we propose to describe in a future paper.

The iron of which the U and the straight cores were made was found to be exceedingly plastic as regards molecular magnetic polarity. In a few seconds after the cessation of an electric current from twenty quart Bunsen cells acting through the above helices, they were incapable of attracting and holding even fine iron filings.

The U magnet tested with a suspended magnetic needle was found to retain some magnetic polarity after many days; in fact, it is doubtful if the magnetism ever entirely disappeared, except when the core was subjected to special treatment.

On the other hand, the straight cores lost their induced magnetism more rapidly, and when, having been demagnetized either by time or by the mode described further on, they were placed in the line of the magnetic dip, they showed poles in accordance therewith; and on reversing the position of the core, these poles were immediately reversed without its being necessary to resort to striking the bars or other means of putting them in a state of vibration. It was thus demonstrated to our minds that if iron of similar quality, and in this form, were made use of for the electro-magnet cores in a dynamo-electric machine, the initial force producing the electric currents of the machine could not be due to residual magnetism, but rather to the lines of magnetic force of the earth.

The current from four Bunsen cells sent round the U magnet fixed the armature so firmly that it could not be pulled, or even slid off, by the utmost exertion of one man's strength.

On breaking battery contact, if both poles were completely covered, a direct pull failed to separate armature and magnet. The armature could, however, though with difficulty, be slid off; the difficulty of movement greatly increasing as the edge of the poles was approached. For instance, on attempting to slide the armature off the north, the south, or both poles, the resistance became greater as the point of final communication between the poles through the moving armature was approached. This was found to be the case whatever time had passed between the rupture of contact and the first movement of the armature. (Sometimes many days elapsed.) In very many experiments it was found, moreover, that, provided neither pole had been completely uncovered, on sliding back the armature to its normal position, the magnet, which with its stand and coils weighed over 58 lbs., could be lifted by it.

A current from four Bunsen cells, almost momentary in duration, sufficiently magnetised the core to produce all the above effects.

If, whilst the current flowed round the U magnet, the armature

rested on one pole only, it was of course strongly held ; but on breaking contact it was at once set free, and fell off if not balanced ; the magnetism of the U core immediately falling to its minimum, as shown by suspended test needles. If, however, the most minute point of connexion existed between the armature and the other pole, in addition to its complete contact with the one it covered, it continued to be firmly held long after battery contact was broken.

It being thought that possibly the effects described were partly due to molecular attraction of the iron atoms when brought into close contact under magnetic stress, the poles were coated with a layer of tallow, but if this was sufficiently thin, the magnet could still be lifted by the armature after breaking battery contact. When the tallow was broken into small lumps, allowing light to be seen between magnet and armature, the same result was obtained.

Thus absolute metallic contact was found to be unnecessary for the retention of a considerable amount of magnetism by the U core and its armature, when in magnetic circuit. With a piece of writing paper interposed between the poles and armature, they were held together with great force long after battery contact was broken ; but when the distance was increased by the interposition of cards, nails, or wires, to  $\frac{1}{16}$  of an inch, the residual attractive force was very much lessened. When the magnetic circuit becomes more open the residual magnetism dies away in about the same proportion as the attractive force of core and armature, whilst under the influence of the battery current it becomes less when the distance between them is increased.

Interposition of thick glazed note paper caused such a diminution of the residual magnetism that the magnet could no longer be lifted by the armature.

The experiment was varied by putting lengths of fine silk thread straight across between the armature and the magnet ; in this, as in the former experiments, the armature was firmly held, and the magnet could be lifted by it. There was no point of actual metallic contact, and light could be seen over both magnetic fields, except at the thin lines where the silk threads were. The 58 lb. magnet, when lifted by the armature, was thus literally suspended in the air (like Mahomet's coffin) by the magnetism remaining in the almost closed circuit, and this long after the exciting electric current had ceased. (The experiments were made at intervals of four hours, twenty-four hours, three days, four days ; the armature had always ultimately to be wrenched off.)

The same result was obtained with plates or slips of zinc, copper, platinum, silver, and aluminium foils, gutta-percha tissue, embroidery cotton, &c., and appeared to depend entirely on the distance between poles and armature, irrespective of the nature of the interposed body.

When the straight cores were placed on the poles of the U magnet, and a current passed round the latter, attraction ceased the moment the battery contact was broken; but if, while the current was passing, the armature was placed on the poles of the cores, the whole system was firmly held together, though the current no longer flowed.

There would appear to be no limit to the length of time during which the stored-up magnetic force exerts itself in such metallic circuits (closed, or nearly so) as are described above, for it was found that, after periods varying from one to fourteen days from the time of a momentary passage of an electric current round the cores, the attractive force was as great, or even greater, than at the first moment.

A small electro-magnet, U-shaped, with limbs 6 inches long, having a core of  $\frac{3}{4}$ -inch iron, and helices consisting of 4 layers of No. 16 covered copper wire, had for its armature a similar U core uncoiled. The uncoiled U was hung up, and the electro-magnet held beneath it, the poles of each being opposed: a current from four Bunsen cells was then sent through the coils for a few seconds. Not only did the electro-magnet (weighing, with its coils, several pounds) remain firmly attached to its armature, but the hanging on to it subsequently of 8 pounds additional weight failed to detach it.

A further proof of the large amount of magnetism held captive in a circuit thus closed was afforded by the following experiments. On connecting the ends of the wires from the helices with a galvanometer and resistance-coil, deflections varying from  $40^\circ$  to  $90^\circ$  were obtained with a resistance of 1,700 ohms in circuit each time the armature was forced away from the poles of the large U magnet, after the passage of a current from four cells of a few seconds' duration. By careful manipulation, sparks between the ends of the helix wires were also obtainable each time the closed magnetic circuit was opened. (In one case a week had elapsed betwixt the passage of the current and obtaining of the spark.)

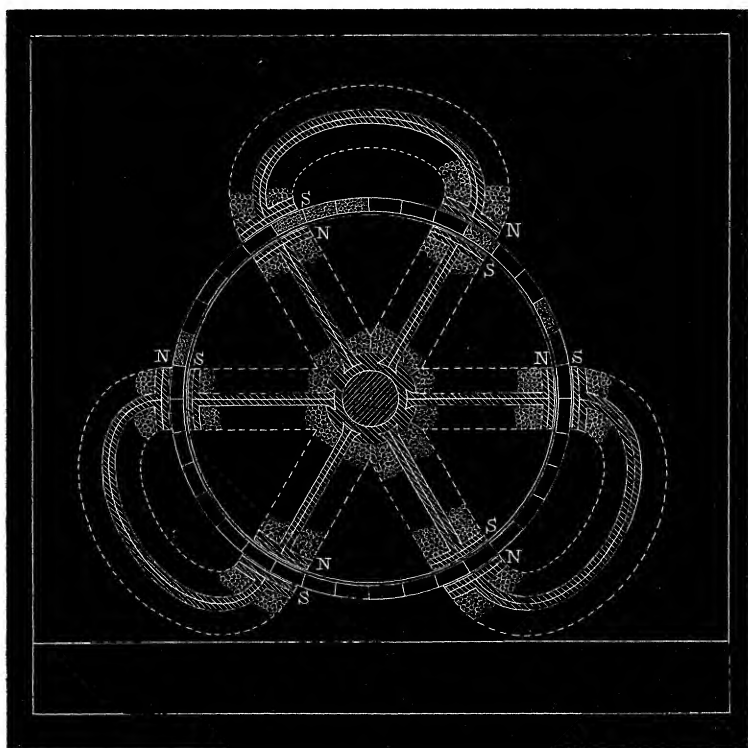
In all these experiments, when the circuit was completely closed there was no external magnetism apparent, but on slightly breaking contact between the poles and armature, magnetic poles could be detected. Slight irregularities of the surfaces in contact likewise caused the development of poles.

A heavy magnetic needle, 4 feet distant from the magnet, if deflected by the U magnet, uncovered by its armature,  $45^\circ$ , would fall back to  $5^\circ$  when the current ceased. If the poles were now covered by the armature, the needle went to  $0^\circ$ . Passage of the current from four cells would now give a deflection of about  $38^\circ$ ; on the current ceasing the needle would come back to  $0^\circ$ , and rise again to  $5^\circ$  on removal of the armature: but if, instead of immediately pulling off the armature, the two ends of the wires of the helices were connected

together, and then the armature was forced off, the needle would swing  $20^\circ$  and fall back to  $5^\circ$  very slowly (in about fifteen minutes).

If both poles of the **U** magnet were caused to be of the same name, and the armature placed upon them, there was no attraction after breaking battery contact.

The straight cores, if placed upon the **U** magnet connected by the armature, and then magnetised in such a way that the poles of the cores faced like poles of the **U** magnet, retained no magnetic polarity when taken away from the system, whereas when they formed part of such a closed circuit as we have above described, the bars retained sufficient polarity to affect a magnetic needle for some time.



We may here remark that the attractive force of electro-magnets for each other, in what we call open circuit, is not nearly as great as in a closed circuit. For instance, the **U** magnet could not be lifted by the straight cores placed upon its poles, even with a current from six Bunsen cells running round the helices; but on bridging the circuit with the armature the whole mass, weighing 82 lbs., could be raised from the ground with the current of only two cells, and quite irre-

spective of the position of the exciting helices, whether both were on the magnet, both on the cores, or one on the magnet and one on a core.

From the foregoing experiments it appears clear that the more near the approach to a closed magnetic circuit, the stronger is the field of force, and the longer is retained the magnetism of the mass or masses of iron constituting the circuit. The same rule holds good with regard to permanent magnets. In closed circuits the attractive force is at its height, and diminishes in intensity as the magnetic field is more extended. But the parallel goes beyond this, for the more open the magnetic field, the more rapidly is the magnetic force itself dissipated.

These principles have guided us in the construction of a dynamo-electric machine of whose magnetic circuits we here present a sketch, and which we hope to describe more fully in a future paper.

In the accompanying diagram six fixed electro-magnets are shown, having alternate poles, opposite to which, and at a very short distance, are placed three other electro-magnets so arranged with opposing poles as to form three nearly closed circuits. Coils of wire are made to revolve so as to cross the intervals between these opposing poles, and the electric currents induced in the moving coils are made to pass round the electro-magnets.

IV. "Further particulars of the Transit of Venus across the Sun, December 9, 1874; observed on the Himalaya Mountains, Mussoorie, at Mary-Villa Station, Lat.  $30^{\circ} 28' N.$ , Long.  $78^{\circ} 3' E.$ , height above sea 6,765 feet, with the Royal Society's 5-inch Equatoreal." Note III. By J. B. N. HENNESSEY, F.R.S. Received October 4, 1879.

1. The object of the present note is to add to Notes I and II\* some particulars of the transit not detailed in those notes. The latter contained only sufficient extracts from my observatory notes in connexion chiefly with the three contacts which I observed; as, however, various other facts, besides the contacts, were developed in course of the transit, and elicited remarks from me at the time, it seems desirable that a complete transcript of these observatory notes should also be put on record; both in connexion with what hereafter follows, and also to meet any possible future requirements of details, such as expressed by Captain Tupman in his discussion of the mean solar parallax.†

\* See "Proc. Roy. Soc." Vol. xxiii, pp. 254, 379.

† Royal Astronomical Society, "Monthly Notices." Vol. xxxviii, p. 452.  
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